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The Translation from In Vitro Bioactive Ion Concentration Screening to In Vivo Application for Preventing Peri-implantitis

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Introduction

Peri-implantitis is a typical pathological condition characterized by the destructive inflammation in the soft tissue and the progressive loss of supporting bones. The use of biomaterials as carriers of bioactive ion coatings is a promising approach. However, determining the effective dosage of each ion to achieve an in vivo application of the in vitro screening is challenging. Here, we selected zinc and strontium ions to provide multiple effects on antibacterial activity and osteogenesis. The optimal coating with effective release concen-trations of the two ions was obtained after the two-step screening from in vitro testing. This type of in vivo bioactive ion usage leads to an enhanced osseointegration during the immediate implantation in a periodontitis -affected environment and prevents soft tissue inflammation and bone resorption in an inflammatory environment. The new biologically active ion screening method verify the effectiveness of this clinical translation and its potential for large -scale production and could determine the effective dosage of each ion for a specific application.

Purpose

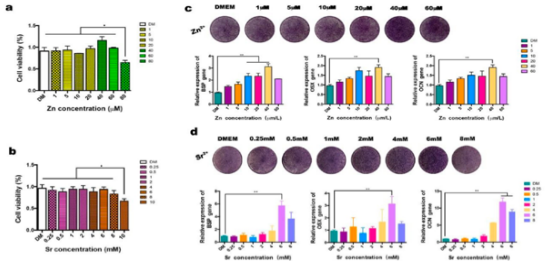
- **Provide a theoretical basis for the amount of active ions used on the surface of the implant.**
- **Provide theoretical basis for preventing peri-implant inflammation and improving implant survival rate and success rate**
- **Promote clinical transformation.**

Methods and Materials

- ***Optimizing the Zn2+ and Sr2+ Concentration for Osteogenic Induction :***
  - CCK-8、ALP Staining、Real-time PCR: OCN/BSP/OSX
- ***Molecular Basis Analysis of Zn2+ and Sr2+ Osteogenic Induction :***
  - BCA Method、Western blot
- ***Verification of Antibacterial Efficacy of Zn2+ and Sr2+ and Their Combination :***
  - Live/dead Bacterial、SEM、CLSM、Crystal violet staining、Growth curves
- ***Specimen Preparation and Characteristics :***
  - Micro-arc oxidation、SEM、TEM、XRD、
- ***Second Screening by Biocompatibility and the Osteogenic Differentiation Analysis :***
  - IF-OCN、IF-Fibronectin、ALP-Staining、RT-PCR
- ***Inhibitory Effect of Substrates on the Pathogenic Bacteria :***
  - Counting、TEM、SEM、Live/Dead
- ***In Vivo Application for Canine Periodontitis :***
  - X-ray、Micro-CT、Van Gieson's picrofuchsin
- ***In Vivo Application for Canine Peri-implantitis :***
  - X-ray、Micro-CT、H.E. Staining

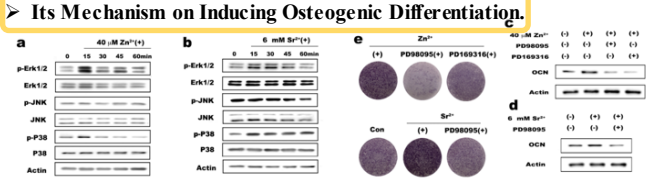
Results

In Vitro Bioactive Ion Concentration Screening



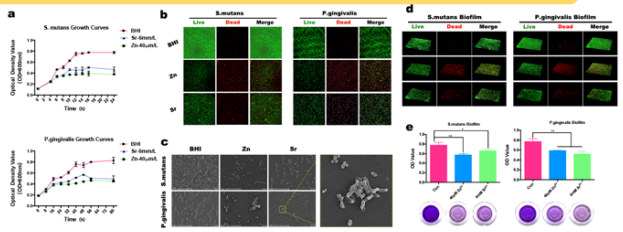
- The two ionic products promoting osteogenic differentiation at a certain concentration.

Its Mechanism on Inducing Osteogenic Differentiation.



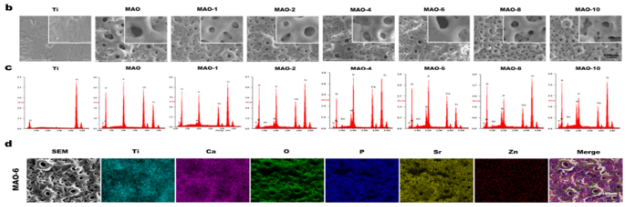
- Investigation of the mechanism of osteoinduction of two ions.

Resistance to Pathogenic Bacteria Leading to Peri-implantitis.



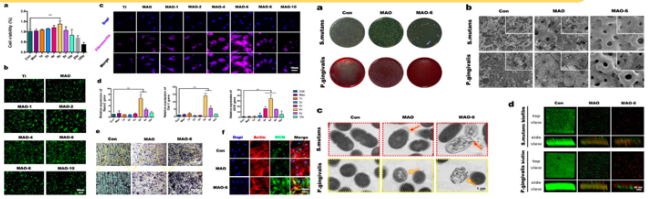
- Antibacterial ability of the two ions.

Fabrication and characterization of the templates.



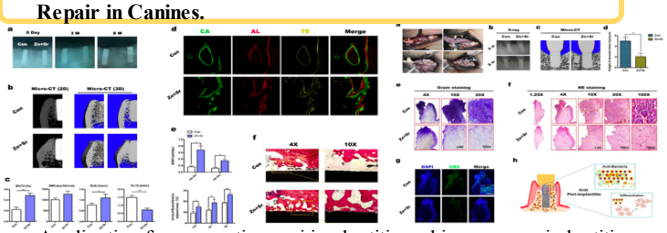
- Fabrication and characterization of the templates.

Screening the Best Ion Concentration for In Vivo Application.



- Anti-related bacterial effect and osteogenic induction of the coatings.

Application for Preventing Peri-Implantitis and Promoting Bone Repair in Canines.



- Application for preventing peri-implantitis and in severe periodontitis

Conclusions

- **The prepared implants with a specific concentration of zinc and strontium coating effectively prevent the occurrence of peri-implantitis.**
- **In the immediate implant model of severe periodontitis, the speed of osseointegration was improved, which is beneficial to the extending the implant life and improving the survival rate.**
- **At the same time, the two-step screening method successfully provided a reference protocol for large-scale production and processing of biologically active implants, which promotes the utilization of fourth-generation implants from laboratories to clinical applications.**